BL-4A/2012G652

Redox states of shergottite Martian meteorites as inferred from iron micro-XANES measurements of maskelynite

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1 Introduction

All known Martian meteorites are igneous rocks and are important for understanding the evolution of Martian igneous history [e.g., 1]. Shergottites constitute the largest group of Martian meteorites and have been classified into three subgroups by light rare earth element (REE) abundance: depleted, intermediate and enriched shergottites [e.g., 2]. Recent petrological and isotopic studies have revealed that shergottites show obvious correlations between oxygen fugacity (fO_2) and geochemical characteristics, and such a correlation must have important information about their mantle sources directly relevant to the Martian evolution [e.g., 3]. From such studies, there are two models regarding the two geochemical source reservoirs for the shergottites. One model proposes assimilation of oxidized crust by mantle-derived, reduced magmas [4,5]. The other model proposes mixing of two distinct mantle reservoirs during melting [2,3,6]. In this study we focused on the Fe valence states of maskelynite (shocked plagioclase glass) in Martian meteorites with the synchrotron radiation (SR) micro-XANES technique to estimate their redox states.

2 Samples

We analysed thirteen shergottites by micro-XANES analysis. The samples are two geochemically depleted (Dar al Gani 476 and Dhofar 019), four geochemically intermediate (EETA 79001 lithology A, ALH 77005, LEW 88516, and NWA 5029), and seven geochemically enriched (NWA 856, Zagami, Shergotty, RBT 04262, NWA 4468, NWA 1068, and LAR 06319) shergottites.

3 Experiment

We performed SR Fe-XANES analysis at BL-4A to estimate the Fe^{3+}-Fe^{2+} peak-intensity ratios of maskelynite (hereafter, $Fe^{3+}/\Sigma Fe$). The transmitted and florescent X-rays were measured by an ionization chamber and Si (Li) detector, respectively. The angle between the incident beam and the detector was fixed at 90^o [7]. K-B mirrors were used to focus the beam to about ~5 x 6 μm square on the specimen. We scanned energy from 7100 to 7180 eV, using a 0.11 eV step for the pre-edge and main-edge regions. The energy was calibrated by defining the first derivative peak of Fe foil to be 7111 eV and standard kaersutites with known $Fe^{3+}/\Sigma Fe$ ratios at regular intervals to determine the energy reproducibility [e.g., 8]. The energy interval was counted between 5-30 live seconds, depending upon the Fe concentration in the samples.

4 Results and Discussion

The $Fe^{3+}/\Sigma Fe$ ratios of the maskelynite in the analyzed shergottites showed wide ranges (depleted: 0.39-0.49, intermediate: 0.13-0.66 and enriched: 0.40-0.81). The important observation is that the $Fe^{3+}/\Sigma Fe$ ratios for maskelynite in intermediate shergottites show a very wide range, exceeding the ratios obtained for those in depleted and enriched shergottites. In particular, the $Fe^{3+}/\Sigma Fe$ ratios for maskelynite in ALH 77005 and NWA 5029 were lower than those in the depleted shergottites. The low $Fe^{3+}/\Sigma Fe$ ratios for maskelynite in ALH 77005 is consistent with the low oxygen fugacity as reported by [9]. This result also suggests that oxygen fugacity has little relationship with light rare earth element abundance. Therefore, the intermediate shergottites could not have been produced through the simple mixing of depleted and enriched mantle reservoirs. A mantle reservoir distinct from the depleted and enriched reservoirs is required for the formation of intermediate shergottites.

5 Conclusions

In this study we demonstrated that Fe micro-XANES analysis of maskelynite is sensitive enough to be used to analyze and compare shergottites formed at different fO_2. Because we found a large variation for Fe valences of maskelynite in intermediate shergottites, we suggest that a mantle reservoir distinct from the depleted and enriched ones is required to form intermediate shergottites.

Acknowledgement

We are grateful for the assistance of Prof. A. Iida during the XANES experiments.

References

[1] H. Y. McSween, *MAPS* **37**, 7 (2002).
[2] S. J. K. Symes et al., *GCA* **69**, 17 (2008).
[3] L. E. Borg and D. S. Draper, *MAPS* **38**, 1713 (2003).
[4] C. D. K. Herd et al., *GCA* **66**, 2025 (2002).
[5] M. Wadhwa, *Science*. **291**, 1527 (2001).
[6] A. H. Treiman, *APS* **38**, 1849 (2003).
[7] A. Iida and T. Noma, *JJAP* **32**, 2899 (1993).
[8] A. Monkawa et al., *MAPS* **41**, 1321 (2006).
[9] C. D. K. Herd, *MAPS* **38**, 1793 (2003).

Research Achievement

W. Satake: Student Travel Award, 73rd Annual Meeting of the Meteoritical Society, 2010, New York, USA.

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